

CLAIMS

What is claimed is:

1. An integrated circuit with a bi-directional level shifter, the bi-directional level shifter comprising:
 - a first signal terminal operable as an input and an output, wherein when being operable as an input, the first signal terminal receives a first signal compatible with a first voltage domain of the integrated circuit and wherein when being operable as an output, the first signal terminal provides a shifted signal compatible with the first voltage domain of the integrated circuit;
 - a second signal terminal operable as an output and an input, wherein when being operable as an output, the second signal terminal provides a shifted signal compatible with a second voltage domain of the integrated circuit and wherein when being operable as an input, the second signal terminal receives a second signal compatible with the second voltage domain of the integrated circuit; and
 - level shift circuitry coupled between the first signal terminal and the second signal terminal, the level shift circuitry translating the first signal compatible with the first voltage domain to the shifted signal compatible with the second voltage domain when the first signal terminal is operable as an input, the level shift circuitry translating the second signal compatible with the second voltage domain to the shifted signal compatible with the first voltage domain when the second signal terminal is operable as an input.
2. The integrated circuit of claim 1, wherein the level shift circuitry further includes at least one current cut-off transistor, wherein responsive to being non conductive, the at least one current cut-off transistor operates to cut off current flowing in a current path between a first voltage domain voltage supply and second voltage domain voltage supply.
3. The integrated circuit of claim 2, further wherein the at least one current cut-off transistor includes a first cut-off transistor disposed within the first voltage domain and a second transistor disposed within the second voltage domain.

4. The integrated circuit of claim 2, further wherein the at least one current cut-off transistor includes first transistor and a second transistor, the first transistor being disposed within the first voltage domain and having a control terminal coupled to a first voltage domain voltage supply, and a current terminal, and the second transistor being disposed within the second voltage domain and having a control terminal coupled to a second voltage domain voltage supply and a current terminal coupled to the current terminal of the first transistor.
5. The integrated circuit of claim 4, wherein the first transistor is characterized as in NFET and the second transistor is characterized as an NFET.
6. The integrated circuit of claim 1 wherein the level shifter has only signal line that crosses a domain boundary between the first voltage domain and the second voltage domain.
7. The integrated circuit of claim 1 wherein the level shift circuitry comprises:
a current path between the first signal terminal and the second signal terminal, the current path including a first transistor and a second transistor, the first transistor being disposed within the first voltage domain and having a first current terminal coupled to the first signal terminal, a control terminal coupled to a first voltage domain voltage supply, and a second current terminal, and the second transistor being disposed within the second voltage domain and having a first current terminal coupled to the second signal terminal, a control terminal coupled to a second voltage domain voltage supply, and a second current terminal coupled to the second current terminal of the first transistor.
8. The integrated circuit of claim 7 wherein the current path is the only current path of the level shift circuitry to cross a domain boundary between the first voltage domain and the second voltage domain.
9. The integrated circuit of claim 7 wherein the level shift circuitry further comprises:
a first transistor located in the first voltage domain and having a first current terminal coupled to the first voltage domain voltage supply and a second current terminal coupled to the current path;

- a second transistor located in the first voltage domain and having a first current terminal coupled the first voltage domain voltage supply and a second current terminal coupled to a control terminal of the first transistor, and a control terminal coupled to the current path;
 - a third transistor located in the second voltage domain and having a first current terminal coupled to the second voltage domain voltage supply and a second current terminal coupled to the current path;
 - a fourth transistor located in the second voltage domain and having a first current terminal coupled the second voltage domain voltage supply, a second current terminal coupled to the control terminal of the third transistor, and a control terminal coupled to the current path;
10. The integrated circuit of claim 1 wherein the level shift circuitry further comprises:
- a first transistor located in the first voltage domain and having a first current terminal coupled to a first voltage domain voltage supply and a second current terminal coupled to the first signal terminal;
 - a second transistor located in the first voltage domain and having a first current terminal coupled the first voltage domain voltage supply, a second current terminal coupled to the control terminal of the first transistor, and a control terminal coupled to the first signal terminal;
 - a third transistor located in the second voltage domain and having a first current terminal coupled to a second voltage domain voltage supply and a second current terminal coupled to the second signal terminal;
 - a fourth transistor located in the second voltage domain and having a first current terminal coupled the second voltage domain voltage supply, a second current terminal coupled to the control terminal of the third transistor, and a control terminal coupled to the second signal terminal.
11. The integrated circuit of claim 1 wherein the integrated circuit further comprises:
- a first circuit coupled to the first signal terminal, the first circuit including circuitry to enable the first circuit to receive the shifted signal from the first signal terminal and circuitry to enable the first circuit to provide the first signal to the first signal terminal;

a second circuit coupled to the second signal terminal, the second circuit including circuitry to enable the second circuit to receive the shifted signal from the second signal terminal and circuitry to enable the second circuit to provide the second signal to the second signal terminal.

12. A method comprising:

providing a first signal to a first signal terminal of a level shifter, the first signal compatible with a first voltage domain, wherein in response to the providing the first signal, the level shifter provides at a second signal terminal of the level shifter a shifted signal compatible with a second voltage domain; and providing a second signal to the signal terminal of the level shifter, the second signal compatible with the second voltage domain, wherein in response to the providing the second signal, the level shifter provides at the first signal terminal a shifted signal compatible with a first voltage domain.

13. The method of claim 12 further comprising:

cutting off current of a current path of the level shifter between a first voltage domain voltage supply and a second voltage domain voltage supply when the voltage at the first signal terminal is at a high voltage.

14. The method of claim 13 wherein the cutting off a current path further includes making non conductive a transistor of a first transistor and a second transistor, wherein the first transistor is located in the first voltage domain and has a control terminal coupled to the first voltage domain voltage supply and the second transistor is located in the second voltage domain and has a control terminal coupled to a second voltage domain voltage supply, wherein the first transistor is made non conductive to cut off the current path when the first voltage domain voltage supply is lower than the voltage of the second voltage domain voltage supply and the second transistor is made non conductive when a voltage of the second voltage domain voltage supply is lower than a voltage of the first voltage domain voltage supply.

15. The method of claim 12 further comprising:
enabling circuitry of a first circuit coupled to the first signal terminal and located in the first voltage domain to provide the first signal to the first signal terminal;
enabling circuitry of the first circuit to receive the shifted signal from the second signal terminal.
16. An integrated circuit with a level shifter, the level shifter comprising:
a first signal terminal configured to receive a first signal compatible with a first voltage domain of the integrated circuit;
a second signal terminal configured to output a shifted signal compatible with a second voltage domain of the integrated circuit, wherein the second voltage domain includes a power supply voltage that is higher than a power supply voltage of the first voltage domain; and
level shift circuitry located in the second voltage domain, the level shift circuitry translating the first signal received via a signal line from the first voltage domain to the shifted signal and including means for cutting off current of a current path including the signal line sourced by a second voltage domain supply when the signal line is at high voltage.
17. The integrated circuit of claim 16, wherein the means for cutting off current includes at least one transistor coupled between the second voltage domain supply and the signal line.
18. The integrated circuit of claim 17, wherein the at least one transistor includes an NFET.
19. The integrated circuit of claim 17, wherein the at least one transistor includes a first transistor having a current terminal coupled to the signal line and a control terminal coupled to a bias circuit for maintaining a bias voltage on the control terminal, wherein the bias voltage is in a range between the power supply voltage plus a threshold of the first transistor and two transistor threshold voltages including the threshold voltage of the first transistor.
20. The integrated circuit of claim 19, wherein the bias circuit includes a conductor coupled to a second voltage domain supply.